A mini project report on

RAILWAY ACCIDENT PREVENTION AND SIGNALING INNOVATION

A Dissertation Submitted in partial fulfillment of the requirement
for the award of degree of

BACHELOR OF TECHNOLOGY
In
Electronics and Communication Engineering
By

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2024-2025

CERTIFICATE

This is to certify that the project report entitled **"RAILWAY ACCIDENT PREVENTION AND SIGNALING INNOVATION"** submitted by

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In partial fulfillment of the requirement for the award of the degree of **Bachelor of Technology** in **Electronics and Communication Engineering** to the Jawaharlal Nehru Technological University, Hyderabad is a record of Bonafide work carried out by them under our guidance and supervision

The results presented in this thesis have been verified and are found to be satisfactory. The results embodied in this thesis have not been submitted to any other University for the award of any other degree or diploma.

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Presented by

ENUMULA JOSHUA PAUL

Abstract

The increasing volume of rail traffic has heightened the risk of accidents at level crossings. To mitigate this risk, this project proposes an innovative automated level crossing barrier and signalling system. The system utilizes an Arduino UNO microcontroller to process sensor data and control the barrier and warning signals.

Infrared sensors are strategically placed to detect approaching trains. When a train is detected, the Arduino UNO processes the sensor data and activates a servo motor to lower the barrier. Simultaneously, a warning signal, such as a flashing light or a loud siren, is activated to alert pedestrians and vehicles. The system is designed to provide a reliable and timely response to prevent accidents.

To enhance the system's performance, future research could explore the integration of additional sensors, such as ultrasonic sensors or radar, for improved detection accuracy. Additionally, incorporating the system into existing railway signalling infrastructure could enable centralized monitoring and control. By addressing these areas, the proposed system has the potential to significantly enhance railway safety and reduce the frequency of level crossing accidents.

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ABBREVIATIONS

AODV	Ad hoc On-Demand Distance Vector
ARP	Address Resolution Protocol
AWK	AWKWARD
CBR	Constant Bit Rate
DCF	Distributed Coordination Function
DSDV	Destination-Sequenced Distance-Vector Routing
ETX	Expected Transmission Count
IMEP	Internet MANET Encapsulation Protocol
LQSR	Link Quality Source Routing
MAC	Media Access Control
MANET	Mobile Ad-hoc Network
M-DART	Multi-Path Dynamic Addressing Routing
MR-LQSR	A multi-radio LQSR
MSS	Maximum Segment Size
NAM	Network Animator
NIC	Network Interface Card
OTCL	Object Tool Command Language
PUMA	Protocol for Unified Multicasting Through Announcements
TCL	Tool Command Language
TCP	Transmit Control Protocol
TORA	Temporally-Ordered Routing Algorithm
UDP	User Datagram Protocol
UML	Unified Modeling Language

Chapter 1: Introduction

1.1 Level Crossings

Level crossings are intersections where road traffic crosses a railway track at the same level.

1.1.1 Factors Affecting Level Crossings

Several factors influence the design and operation of level crossings:

- **Class of Road:** The importance and traffic volume of the road.
- **Volume of Road Traffic:** The number of vehicles crossing the railway track.
- **TVU (Train Vehicle Unit):** The product of the average number of road vehicles and trains passing the crossing in 24 hours.
- **Visibility Conditions:** The degree to which drivers can see approaching trains.

1.2 Types of Level Crossings

There are two primary types of level crossings:

1. **Manned Level Crossings:** These crossings are staffed by gatekeepers who manually operate gates to control traffic.
2. **Unmanned Level Crossings:** These crossings do not have gatekeepers and rely on warning signals and other safety devices.

Note:

- **TVU (Train Vehicle Unit):** This is a crucial metric used to assess the level of risk at a particular level crossing. A higher TVU indicates a greater potential for accidents, and therefore, more stringent safety measures may be required.

Figure 1.1: types of level crossing

1. Manned Level Crossings

Manned level crossings are employed at locations where the TVU (Train Vehicle Unit) exceeds 3000.

These crossings are equipped with gates and a gatekeeper to ensure safety during train passages.

Key Features of Manned Level Crossings:

- **Gate Operation:** The gatekeeper manually operates the gates to block road traffic when a train approaches.
- **Speed Breakers:** Speed breakers are installed to reduce vehicle speed near the crossing.
- **Caution Boards:** Warning signs and caution boards are placed to alert road users about the upcoming level crossing.

Figure 1.2: Manned level crossing

2. Unmanned Level Crossings

Unmanned level crossings are employed at locations where the TVU (Train Vehicle Unit) is less than or equal to 3000. Unlike manned crossings, they do not have gates or a gatekeeper.

Key Features of Unmanned Level Crossings:

- **Caution and Danger Boards:** Warning signs and caution boards are installed to alert road users about the upcoming level crossing.

- **Height Barriers:** Height barriers may be installed to prevent vehicles from passing under the barrier when it is lowered.

While unmanned crossings are less complex than manned crossings, it's important to note that they still pose significant risks. Road users must exercise caution and adhere to traffic rules when approaching these crossings.

Figure 1.3: Unmanned level crossing

1.1 Level crossing accident scenario in India

Year	LC accidents
1961-70	1394
1970-80	1120
1981-90	677
1991-2000	716
2001-2010	719
2011-2020	359

Table 1.1: Accident data in India

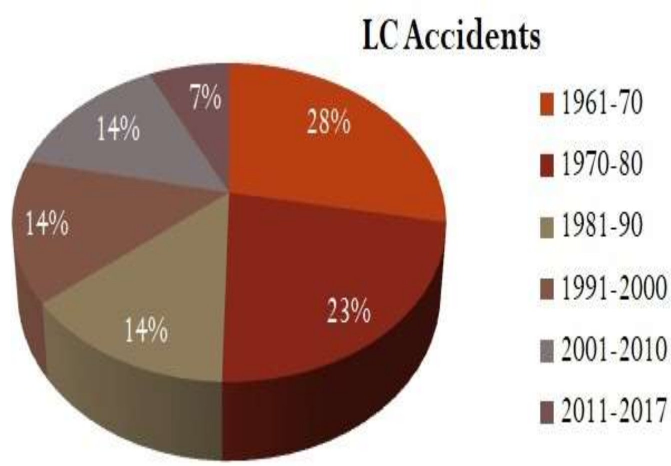

Figure 1.4: accident data in India

1.1.1 Major level crossing accidents in India:

Year	Injury	Fatal
9-12-1964	72	29
16-05-1968	35	30
11-10-1986	60	28
20-03-1991	27	35
10-12-1993	41	38
03-05-1994	0	35
14-05-1996	0	35
25-05-1996	0	25
01-04-1999	0	45
02-02-2005	5	55
07-07-2011	32	38
26-04-2018	8	13

Table 1.2: Major LC Accident data in India

The percentage of level crossing accidents are more, this is due to errors made by gatekeepers and also due to unmanned level crossings. This can be avoided by implementing automatic gate system at level crossings.

Here's how automatic gate systems can improve safety:

1. **Elimination of Human Error:**
    - **Reliable Operation:** Automatic systems rely on sensors and controllers, significantly reducing the chances of errors caused by human negligence or fatigue.
    - **Consistent Response:** The system responds promptly to train arrivals, ensuring timely gate closure and preventing accidents.

2. **Enhanced Safety Features:**
    - **Advanced Sensors:** These systems utilize advanced sensors to detect approaching trains from a distance, allowing for early gate closure.
    - **Warning Signals:** Audible and visual warnings can be activated well in advance, alerting road users about the impending train.
    - **Emergency Stop Mechanisms:** In case of unexpected situations, emergency stop mechanisms can be implemented to halt the gate operation and prevent accidents.
3. **Improved Efficiency:**
    - **Faster Gate Operations:** Automatic systems can operate gates more quickly and efficiently compared to manual operations, reducing delays and improving traffic flow.
    - **Remote Monitoring:** Remote monitoring and control capabilities allow for real-time supervision and troubleshooting, ensuring optimal system performance.

By automating gate operations, we can significantly reduce the risk of accidents, improve road safety, and enhance the overall efficiency of railway operations.

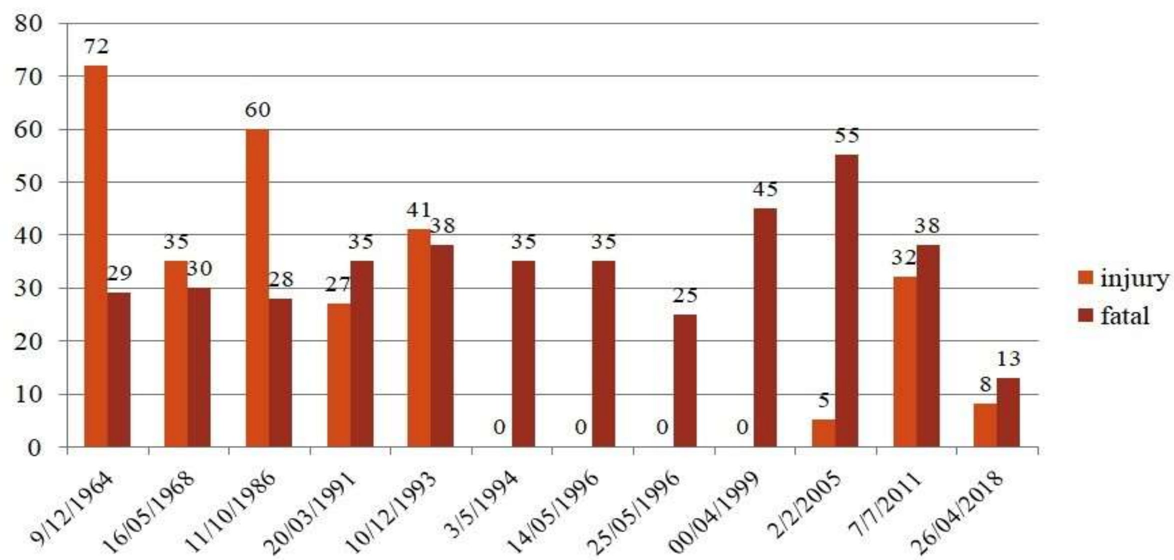

Figure 1.5: Major LC accident data in India

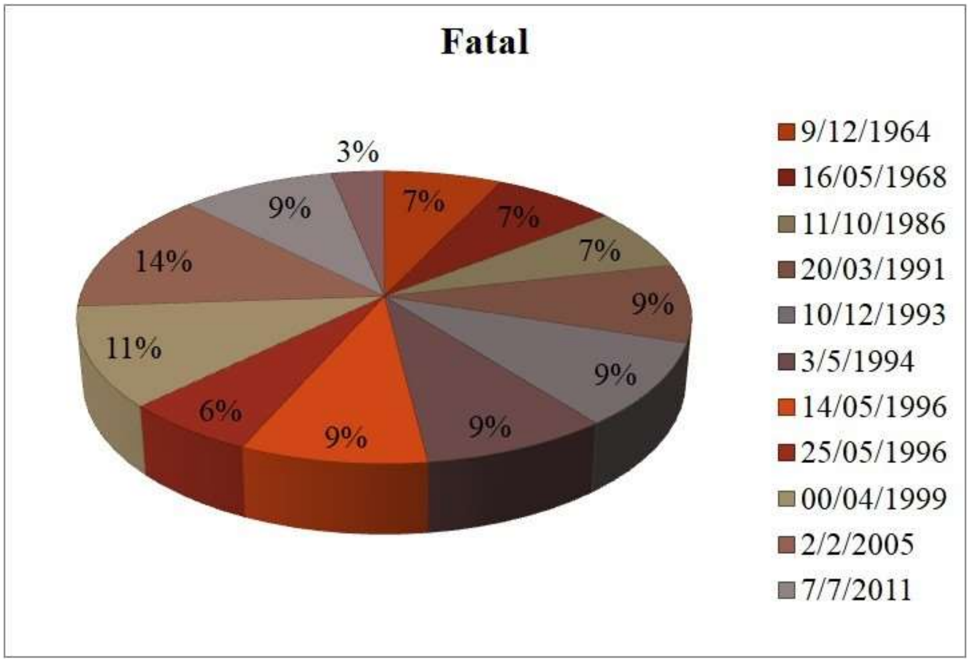

Figure 1.6: fatal accident data in india

1.2 Objectives

The primary objectives of this project are:

- **Automation of Gate Operation:** To replace manually operated gates with an automated system to reduce the time required for gate closure and opening.
- **Enhanced Road Safety:** To significantly reduce the number of accidents at level crossings by implementing an automated safety system.
- **Accident Prevention:** To provide much-needed safety at unmanned level crossings through the deployment of an automatic railway crossing gate controller

Chapter 2: Literature Review

2.1 PLC-Based Railway Level Crossing Gate Control

R. Gopinathan and B. Sivashankar proposed a system utilizing a PLC to control the gate operation. A stepper motor is employed to mechanically open and close the gates. Vibration sensors detect the arrival of a train, triggering the PLC to initiate the gate closure sequence.

2.2 Sensor-Based Automatic Control of Railway Gates

Karthik Krishnamurthi, Monica Bobby, Vidya V, and Edwin Baby presented a system that employs infrared sensors to detect approaching trains. The system also incorporates an obstacle sensor to identify any obstructions on the track. An Arduino microcontroller is used to process sensor data and control the gate operation.

2.3 Arduino-Based Automatic Railway Gate Control and Obstacle Detection System

Dwarakanath S K, Sanjay S B, Soumya G B, Arjun V, and Vivek R developed a system that utilizes an ultrasonic sensor to detect obstacles on the track. Upon detecting an obstacle, the Arduino microcontroller sends an alert message to the nearest railway station via GSM technology.

2.4 Automatic Railway Gate Control System

M. Satya Priya, N. Darani, and S. Indumathi designed a system that employs ultrasonic sensors to detect approaching trains from both sides of the gate. LED indicators are installed to signal road users about the impending gate closure.

Key Considerations and Future Directions

While these existing systems offer valuable insights, there are several areas for improvement and future research:

- **Robustness and Reliability:** Enhancing the system's reliability by incorporating redundant sensors and fail-safe mechanisms is crucial.
- **Advanced Sensor Technologies:** Exploring the use of more advanced sensor technologies, such as LiDAR or camera-based systems, can improve detection accuracy and response time.
- **Integration with Intelligent Transportation Systems (ITS):** Integrating the system with ITS can enable real-time traffic management and optimize gate operations.
- **Cybersecurity:** Implementing robust cybersecurity measures to protect against potential cyberattacks is essential.
- **User-Friendly Interfaces:** Developing user-friendly interfaces for system monitoring and control can simplify maintenance and troubleshooting.

By addressing these aspects, future research can contribute to the development of more sophisticated and reliable automatic railway gate systems, further enhancing safety and efficiency at level crossings.

Conclusion:

The increasing number of accidents at level crossings necessitates the implementation of advanced safety measures. Automatic railway gate systems offer a promising solution to mitigate these risks. By automating the gate operation and incorporating advanced sensor technologies, these systems can significantly enhance safety and efficiency.

The literature review highlights various approaches to automatic gate control, including the use of PLCs, microcontrollers, and sensor-based systems. While these systems have shown potential, there is still room for improvement in terms of reliability, robustness, and integration with advanced technologies

.

Future research should focus on developing more sophisticated systems that can adapt to changing traffic conditions, integrate with intelligent transportation systems, and incorporate advanced cybersecurity measures. By investing in such technologies, we can create safer and more efficient railway networks, reducing the risk of accidents and saving lives.

Chapter 3: Equipment Used

- **Components required :**

1. Arduino Uno Microcontroller
2. IR Sensor
3. Buzzer
4. Micro servo
5. Resistors
6. Jumper Wires

1. Arduino Uno Microcontroller

The Arduino Uno is a versatile open-source microcontroller board based on the ATmega328P chip. It serves as the brain of the system, processing sensor data and controlling the actuators. Key features of the Arduino Uno include:

- **Digital and Analog Input/Output (I/O) Pins:** It has 14 digital I/O pins (6 of which can be used for Pulse Width Modulation - PWM) and 6 analog input pins for connecting various sensors and actuators.
- **Programmability:** The board can be programmed using the Arduino Integrated Development Environment (IDE) via a USB cable. This allows for customization and tailoring of the system's functionality.
- **Power Supply:** The Arduino Uno can be powered by a USB cable or an external 9-volt battery, offering flexibility in deployment scenarios.

The Arduino Uno is a versatile microcontroller board that serves as the brain of the system. It processes sensor data, controls the gate mechanism, and generates alerts. It's programmable using the Arduino IDE, allowing for customization and adaptation to specific requirements.

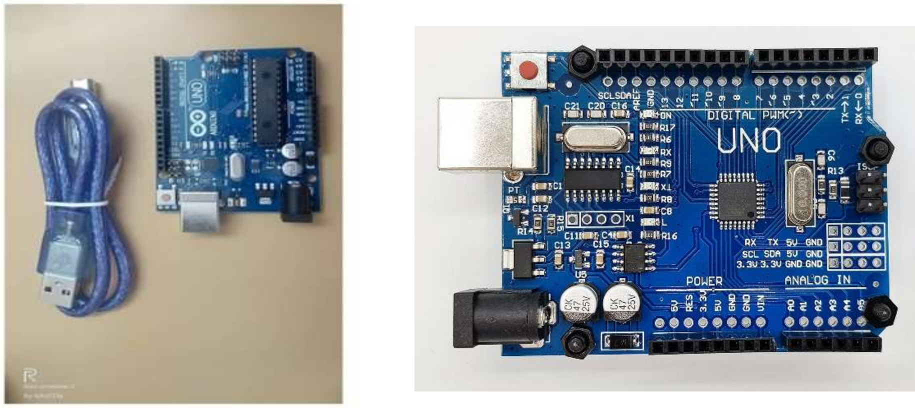

Figure 3.1: Arduino-uno

2. IR Sensor (Infrared Sensor)

The IR sensor plays a crucial role in detecting approaching trains. It operates on the principle of infrared radiation:

1. **Transmission and Reception:** The sensor transmits an infrared signal, and this signal reflects off the surface of an object (in this case, the train) and is received by an infrared receiver.
2. **Wavelength Range:** Infrared radiation occupies a specific portion of the electromagnetic spectrum. The sensor typically operates within the near-infrared region (700nm to 1400nm), which is invisible to the human eye.

Figure 3.2: IR sensor

3. Buzzer

The buzzer serves as an audible alert for road users. It emits a beeping sound when activated, notifying drivers about the closing or opening of the gate.

Figure 3.3: BuzzeR

4. Servo Motor

A servo motor is a precise positioning actuator. It allows for controlled movement of the railway gate:

- **Precise Control:** Unlike regular DC motors, servo motors offer precise control of angular position, velocity, and acceleration.
- **Internal Feedback Mechanism:** This control is achieved through a built-in sensor that provides feedback to the motor, ensuring it reaches the desired position accurately.

Applications: Servo motors are widely used in robotics, CNC machinery, and automated systems, including this railway gate control application

Figure 3:4 Micro servo

Resistors

Resistors are passive electrical components that regulate current flow within the circuit. Their primary function in this system is to:

- **Control Current Flow:** By strategically placing resistors in the circuit, the amount of current delivered to other components like the sensors and actuators can be controlled.
- **Signal Level Adjustment:** Resistors can also be used to adjust signal levels within the circuit, ensuring proper operation of various electronic components.

Value	1 kΩ/ 1000Ω
Type	4 Band Colour Code
Colour Code	Brown, Black, Red, Gold
Multiplier	Red, 100
Tolerance	Gold Band 5%

Table 3.1: Resistor description

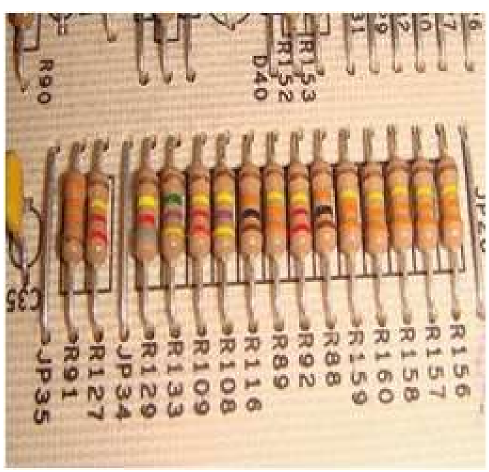

Figure 3.5: Resistors

Additional Notes:

- **Jumper Wires:** These flexible wires are used for establishing connections between different components on the circuit board.
- **Breadboard:** A breadboard is a reusable platform that allows for easy prototyping of electronic circuits without the need for soldering.

By combining these components and programming the Arduino Uno with appropriate logic, an effective automatic railway gate control system can be built.

Chapter 4

METHODOLOGY

4.1 BLOCK DIAGRAM

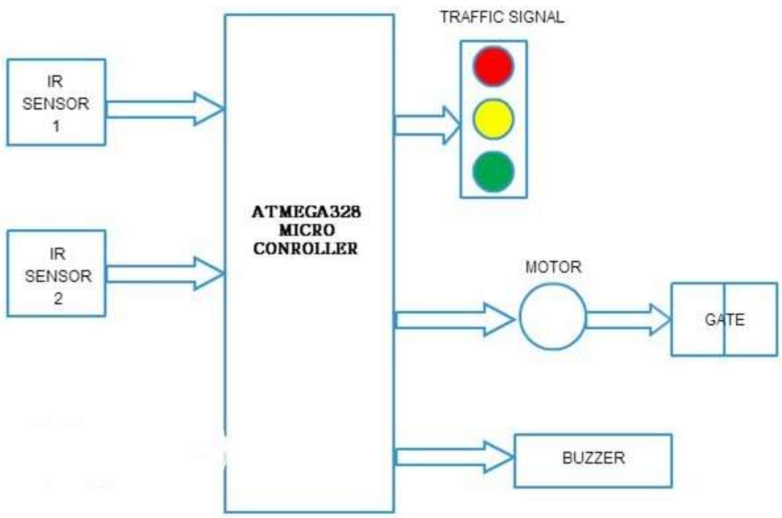

Figure 4.1: block diagram of project

Circuit Diagram:

An Arduino UNO is the base of this circuit and all the other components are connected to this board. Two IR Sensors, IR1, IR2 are connected to pins 3, 5 of Arduino UNO. Three LEDs, red, yellow and green, are connected at pin 11, 12 and 13 respectively. Each of these LEDs are grounded through 1k resistor. A servo motor is connected to pin 9. A buzzer is also connected at pin 3.

When IR1 detects the train coming, it sends a high signal to pin 3. As soon as the Arduino

UNO detects a high signal, it raises the signal at pin 11 and the components connected to this pin shows an output i.e. the yellow LED glows and the buzzer buzzes. and also, IR1 sends a high signal to pin 3 when the train is detected by it. This sends a high signal to pin 12 and pin 9. Hence, the red LED glows and servo motor rotates 90 degrees. When IR2 senses, it sends a high signal to pin 9 and pin 13. Thus, the green LED glows and the servo motor moves another 90 degrees. Fig. 14 shows the block diagram of the system.

4.2 Flow chart for Closing of Level crossing

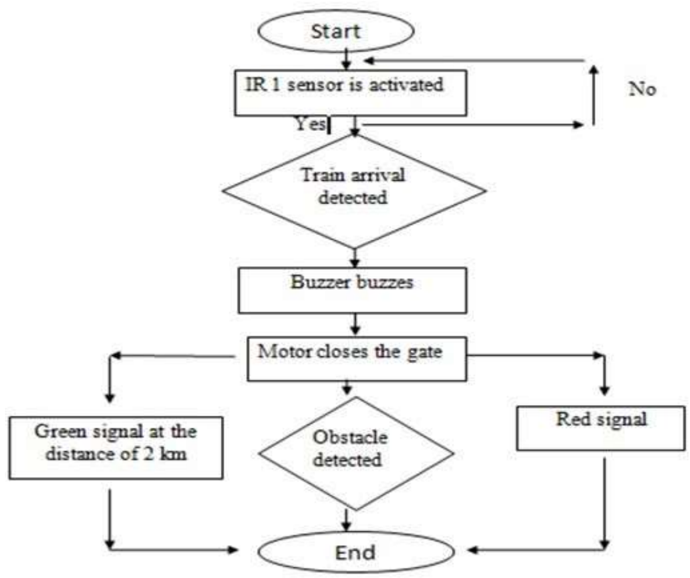

Figure 4.2: flow chart for closing of LC

At the beginning the IR sensor1 senses for the detection of arriving train and the output of sensor1 goes HIGH, that is when the sensor1 senses the train. Then the buzzer and light will be turned ON for the indication to the road users. And the gate will be closed by rotating the Servo motor.

4.3 Flow chart for opening of Level crossing

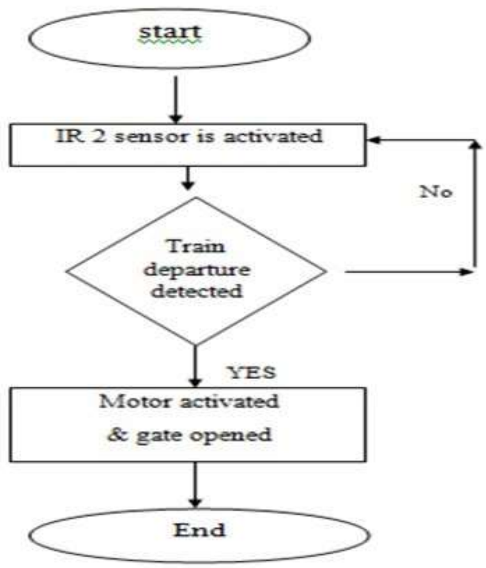

Figure 4.3: flow chart for opening of LC

After the sensor2 output goes HIGH, that is the sensor2 senses the departure of train the buzzer and LED will be turned OFF and then the gate will open.

Chapter 5
Automatic railway gate

5.1 System overview

Sensor based railway gate automation system is developed to automate the process of opening and closing of gate at the railway level crosses. The system detects the arrival and the departure of train for the gate operation using different types of sensors. The proposed system uses three infrared sensors to identify the arrival and departure of trains. The system also implements obstacle sensor which detects any obstacle on the track and controls the operation of the train. Sensors and servo motors are programmed using Arduino micro-controller. The major components used in the automation of railway gate at the level gates are sensors. Sensors that detect the train can be classified into different types such as:

Wheel detecting sensor:

Wheel sensors work on magnetic inductive principle. The DC current which is generated as the output signal from the wheel detectors are used for the detection of train arrival.

Vibration sensor:

Vibration sensors use piezoelectric effect to detect the vibration in the track which detects the arrival and departure of the train. The output signal from the vibration sensor is fed into the micro-controller and it automates the gate operations. The major application of the vibration sensor is collision detection.

IR sensor: IR sensors detect the train using infra-red receiver and transmitter. Infra-red sensors are capable of detecting the presence of an object by sensing the heat being emitted by the object. It emits or detects the radiations to detect the motion of an object surrounding it. The most commonly used sensors for the automatic railway gate system is vibration sensors IR

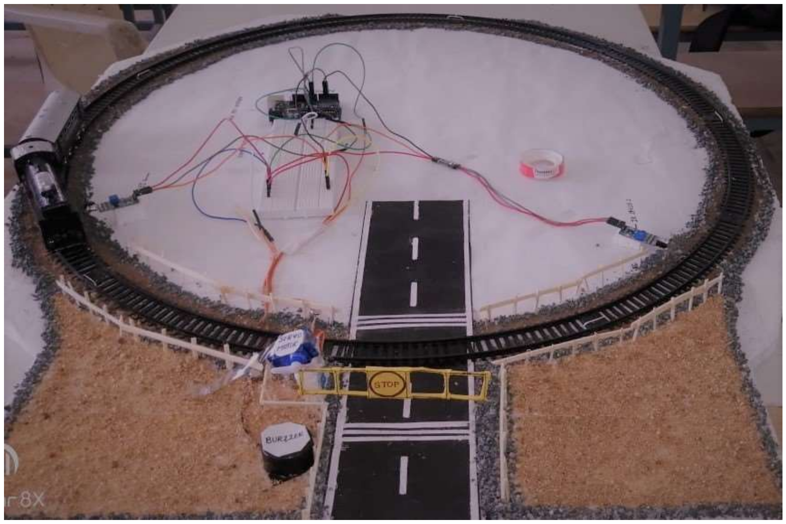

Figure 5.1: Prototype model

5.2 System Architecture

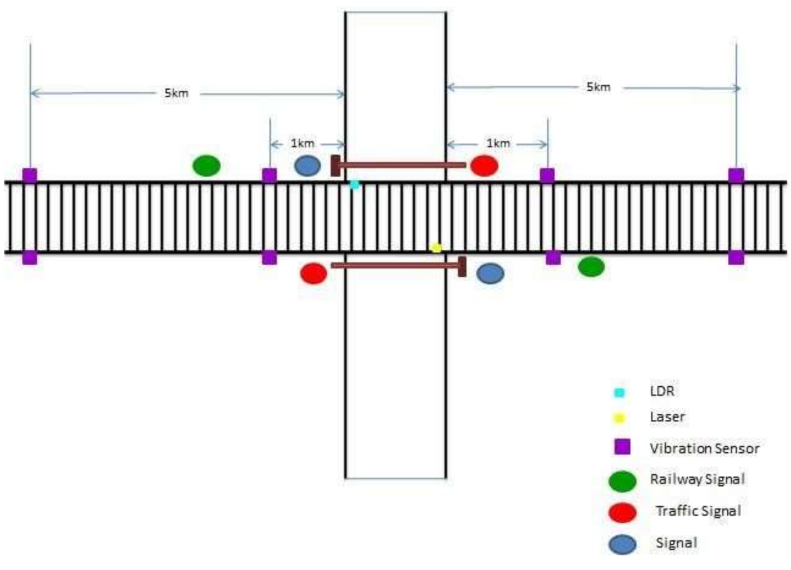

Figure 5.2: Architectural Diagram

In India the maximum speed at which a train moves is 91.82km/hr and the minimum speed of a passenger/goods train is 59km/hr. Hence the ideal distance at which the sensors could be placed to detect the arrival of the train is 5km from the level cross and the departure of the train is 1km and thus the gate will not be closed for more than 8 minutes [1]

. Our paper proposes a system which uses five sensors, four IR Sensors (IR1, IR2, IR3 and IR4), a Light Dependent Resistor (LDR), a laser source (L), counter and one buzzer (B1). In real time, the IR Sensors are placed on the track at a distance of 5km and 1km on both sides of the level crossing. The LDR and laser source is used to detect the presence of an obstacle between the railway gates. The system also uses DC motors to control the operation of the gates. The buzzer is used to indicate the arrival of the train within a stipulated time.

IR1 detects the arrival of a train. Once it detects a train, it sends a signal to B1 and C1, and B1 is triggered and C1 starts count down, and yellow LEDs are switched on for the traffic to know the arrival of the train. The train then travels to IR2. When the train nears IR2, DC motors are powered on. The DC motors starts and the gates begin to close. Parallel red LEDs are switched on. After the train passes the gates and nears IR3, a signal is again sent to the DC motors and the gates open and green LEDs are switched on for the road traffic to pas

Chapter 6: Result and Implementation

System Implementation and Testing:

A physical prototype of the automatic railway gate control system was developed to validate its functionality. The key components of the prototype included:

- **Railway Track:** A miniature railway track was constructed to simulate real-world conditions.
- **Toy Train:** A toy train was used to represent an actual train.
- **IR Sensors:** Two IR sensors were strategically placed to detect the approaching and departing train.
- **Stepper Motor:** A stepper motor was employed to control the movement of the gate.
- **LED Indicators:** LED lights were used to signal the status of the gate (red for closed, green for open, and yellow for caution).
- **Buzzer:** A buzzer was integrated to provide audible alerts to road users.

Gate Operation:

1. **Train Detection:** When the approaching train triggers the first IR sensor, a yellow LED is illuminated, indicating that the gate is about to close.
2. **Gate Closure:** As the train crosses the second IR sensor, the buzzer sounds, and the gate starts closing. The red LED is activated to signal that the gate is closed.
3. **Gate Opening:** Once the train has completely passed the level crossing, the gate starts to open. The green LED is illuminated to indicate that the gate is open.

Obstacle Detection:

To enhance safety, an RF module was installed on the toy train. This module can transmit signals to a control room, alerting operators of any obstacles on the track. If an obstacle is detected, the train can be remotely controlled to stop or slow down, preventing potential accidents.

Overall Performance:

The prototype successfully demonstrated the feasibility of the proposed system. It accurately detected the arrival and departure of the train, controlled the gate operation, and provided timely alerts to road users. The integration of obstacle detection further enhanced the system's safety features.

Future Improvements:

While the prototype proved effective, there are opportunities for further improvement:

- **Robustness:** Enhancing the system's robustness to environmental factors like weather conditions and electromagnetic interference can be explored.
- **Advanced Sensor Technologies:** Incorporating more advanced sensor technologies, such as LiDAR or camera-based systems, can improve detection accuracy and reliability.
- **Integration with Intelligent Transportation Systems (ITS):** Integrating the system with ITS can enable real-time traffic management and optimize gate operations.
- **Cybersecurity:** Implementing robust cybersecurity measures to protect against potential cyberattacks is essential.
- **User-Friendly Interfaces:** Developing user-friendly interfaces for system monitoring and control can simplify maintenance and troubleshooting

Chapter 7: Conclusion and Future Scope

Conclusion

The proposed automatic railway gate control system offers a significant advancement in railway safety. By automating the gate operation, the system effectively eliminates the risk of human error and ensures timely gate closure and opening. The integration of obstacle detection further enhances safety by preventing accidents caused by obstructions on the track.

The system's reliance on infrared sensors, while effective in detecting approaching trains, can be susceptible to environmental factors and obstacles. To address this limitation, future research could explore the use of more robust sensor technologies, such as LiDAR or camera-based systems.

Future Scope

Several avenues for future research and development can further improve the performance and capabilities of automatic railway gate systems:

1. **Advanced Sensor Technologies:**
    - **LiDAR:** LiDAR sensors can provide precise distance measurements and object detection, enabling more accurate and reliable gate control.
    - **Camera-Based Systems:** Computer vision techniques can be employed to analyze video feeds from cameras to detect trains, obstacles, and other relevant information.
2. **Integration with Intelligent Transportation Systems (ITS):**
    - By integrating with ITS, the system can optimize gate operations based on real-time traffic conditions, reducing delays and improving efficiency.
3. **Cybersecurity:**
    - Implementing robust cybersecurity measures is essential to protect the system from cyberattacks and unauthorized access.

4. **User-Friendly Interfaces:**
    - Developing user-friendly interfaces for system monitoring and control can simplify maintenance and troubleshooting.
5. **Real-time Monitoring and Remote Control:**
    - Implementing remote monitoring and control capabilities can enable real-time supervision and troubleshooting, ensuring optimal system performance.

By addressing these areas, future research can contribute to the development of more sophisticated and reliable automatic railway gate systems, further enhancing safety and efficiency at level crossings.

CHAPTER : 8 SOFTWARE PROGRAM CODE OF THE PROJECT

C++

```
#include <Servo.h>

int buzzer = 10;
int s = 9;
int ir1 = 4;
int ir2 = 5;
int a1;
int a2;
Servo s1;
int pos = 0;

void setup() {
  s1.attach(s);
  pinMode(ir1, INPUT);
  pinMode(ir2, INPUT);
  Serial.begin(9600);
  pinMode(buzzer, OUTPUT);
}

void loop() {
  a1 = digitalRead(ir1);
  a2 = digitalRead(ir2);
  Serial.println("ir1");
  Serial.println(a1);
  Serial.println("ir2");
  Serial.println(a2);
  // Delay for better reading (optional, adjust as needed)
```

```
  delay(100);

  if (a2 == LOW && a1 == LOW) {
    s1.write(0);
    Serial.println("gate close");
    tone(buzzer, 1000);
    delay(1000);
    noTone(buzzer);
    delay(1000);
  } else if (a1 == HIGH && a2 == HIGH) {
    s1.write(90);
    Serial.println("gate open");
    delay(500);
  }
}
```

Explanation on program

1. Make initial setting of the signals for the train and road users.
2. Check for the arrival of the train in either direction by the sensors. If the train is sensed go to 3 otherwise go to step2.
3. Make the warning signal for the road users and set the signal for the train.
4. Check for the presence of any obstacles using sensors. If no obstacle, go to step5 otherwise repeat step 4.
5. Close the gate.
6. Change the signal for the train.
7. check for the train departure by the sensor s. if the train sensed to next STEP. Otherwise repeat Step.
8. Open the gate.
9. Go to step 3

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Guide(s): **k Ashok Babu** (Associate Prof)
Student Name : **ENUMULA JOSHUA PAUL**

Academic Year: 2024-2025

Name of Course from which Principles are applied in this project	**Related Course Outcome Number**	**Description of the application**	**Page Number**	**Attained PO**

Guide Signature